Newsjournal of the Society for Industrial and Applied Mathematics sinews.siam.org

siam news

Volume 58/ Issue 5
June 2025

Mathematical Framework Explains Evolutionary Dynamics of Behavior

By Lakshmi Chandrasekaran

If a ninespine stickleback fish could choose between a diet that was rich or poor in nutrients, what would it pick? A 2010 study found that these fish tend to copy each other when choosing a meal, opting for the feeder at which other fish have already foraged [3]. A 2018 mating experiment with fruit flies revealed similar social behavior [1]. The male flies were artificially colored pink or green, and a set of female flies watched other females choose their male partners; the females tended to prefer the same males that were previously selected, even if the colors were reversed. Such behavior, known as *conformity*, is defined as the tendency to copy the majority opinion.

Humans exhibit conformity as well. Our numerous decisions throughout the day—such as what and how much food to eat, when to go to bed, and whether to purchase a particular product—often reflect the behavior of the majority. "Let's say that you want to choose between two restaurants, and you notice that more people are going to one of them," Kaleda Denton, an evolutionary biologist at the Santa Fe Institute, said. "You might think that's a better restaurant, even if the other one has equally good reviews."

The opposing behavior, called *anti-conformity*, involves going against popular conduct — such as picking a unique baby name to stand out. "These processes balance the need for stability and adaptability within populations," Aviv Bergman, a professor at the Albert Einstein College of Medicine, said.

Previous mathematical models of conformity have often focused on discrete decisions (e.g., choosing between two feeders or several products), wherein the most popular decision is simply the most common one. In the case of continuous decisions (e.g., selecting a level of behavior on a spectrum), conformity is sometimes defined as a preference for the population's "mean" behavior.

See **Dynamics of Behavior** *on page 3*

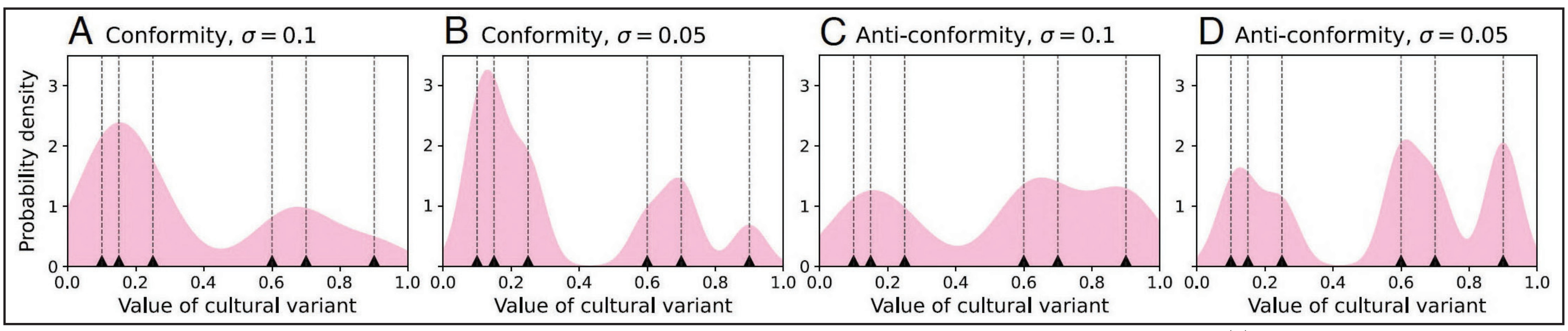

Figure 1. *Probability density that an individual will adopt a continuous cultural variant based on a role model sample, with $k=2$ and either conformity ($d_k(\boldsymbol{x})=0.9$ for* **1a** *and* **1b***) or anti-conformity ($d_k(\boldsymbol{x})=-0.9$ for* **1c** *and* **1d***). The black triangles and dashed lines indicate the sample of $n=6$ role models with variants $\boldsymbol{x}=(0.1, 0.15, 0.25, 0.6, 0.7, 0.9)$. Given this sample, the curves show the probability density for a single individual to adopt a variant; $\sigma=0.1$ for* **1a** *and* **1c** *and $\sigma=0.05$ for* **1b** *and* **1d***. Traits that are clustered together more closely have a higher probability of selection with conformity and a lower probability with anti-conformity. Figure adapted from [2].*

Evaluating the Good and Bad of Artificial Intelligence Tools for Climate Research

By Matthew R. Francis

Climate change—intertwined with habitat loss, resource extraction, and power usage—is arguably the single biggest issue that humanity faces today. Researchers are contemplating all available tools—including machine learning, a term that is often used interchangeably with artificial intelligence (AI)—to model, mitigate, and otherwise prepare for impending crises. However, no one approach is a panacea; scientists who utilize these tools must sort through legitimate use cases, unnecessary deployments, and broader questions about AI's positive and negative effects on the future of the planet.

"AI can be a powerful tool for climate action," Priya Donti of the Massachusetts Institute of Technology said. "[It] enables us to get better foresight on renewable energy; optimize things like heating and cooling systems; and accelerate the scientific discovery and creation of clean technologies, such as next-generation batteries."

During her presentation[1] at the 2025 American Association for the Advancement of Science (AAAS) Annual Meeting,[2] which took place this past February in Boston, Mass., Donti described the delicate balance between AI's climate benefits and its serious ecological drawbacks. "AI is used in ways that accelerate emissions-intensive applications that are counter to climate progress," she said, citing its role in fossil fuel exploration and extraction, as well as the widespread adoption of targeted AI-based advertising that increases consumption and carbon footprint.

In an AAAS session about AI in the era of climate change,[3] Donti's fellow presenters discussed specific issues with AI in primarily nonscientific contexts that are nonetheless relevant to *all* questions that surround AI's application to climate change and other ecological and conservation-related matters. Specifically, they asked the audience to consider the balance between urgent climatological needs and concerns about access to data, algorithms, and natural resources. In other words, does the need for AI in climate settings outweigh the drawbacks? The answer, as always, is that the situation is complicated.

AI Helping Hand

Naturally, not all AI is created equal. For instance, generative AI chatbots and content generators—systems that scrape content from the internet to produce derivative text, images, or video—are in a fundamentally different class than specific scientific applications. This necessary distinction allows scientists to specify the benefits of AI for climate research [1].

Donti co-founded the nonprofit Climate Change AI[4] with Lynn Kaack of the Hertie School in Berlin and David Rolnick of McGill University and Mila – Quebec AI Institute,[5] based on the notion that the proper use of AI can benefit the planet. Beyond the application of machine learning to various problems in energy generation and transmission, the organization also seeks to ensure that the models themselves align with appropriate values. In other words, Donti and her colleagues aim to develop and utilize efficient algorithms and foster

See **Climate Research** *on page 4*

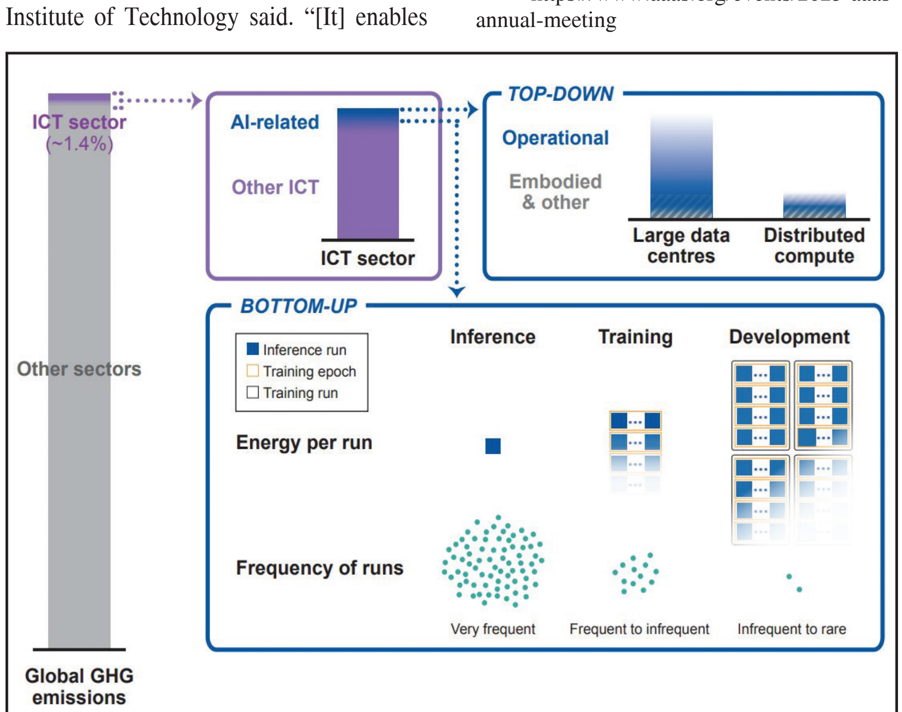

Figure 1. *Breakdown of the contributions to greenhouse gas (GHG) emissions from the information and communications technology (ICT) sector in 2020, with a focus on the specific impacts due to artificial intelligence (AI). The share of impacts from AI has grown in the intervening years, though a lack of transparency on the part of AI and utility companies makes it difficult to gauge the precise contribution to climate change. Figure courtesy of [2].*

[1] https://aaas.confex.com/aaas/2025/meetingapp.cgi/Paper/33562
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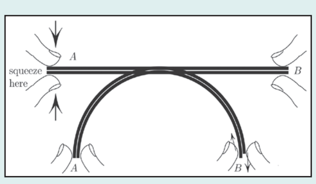
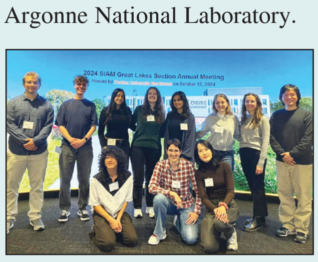
Volume 58/ Issue 5/ June 2025



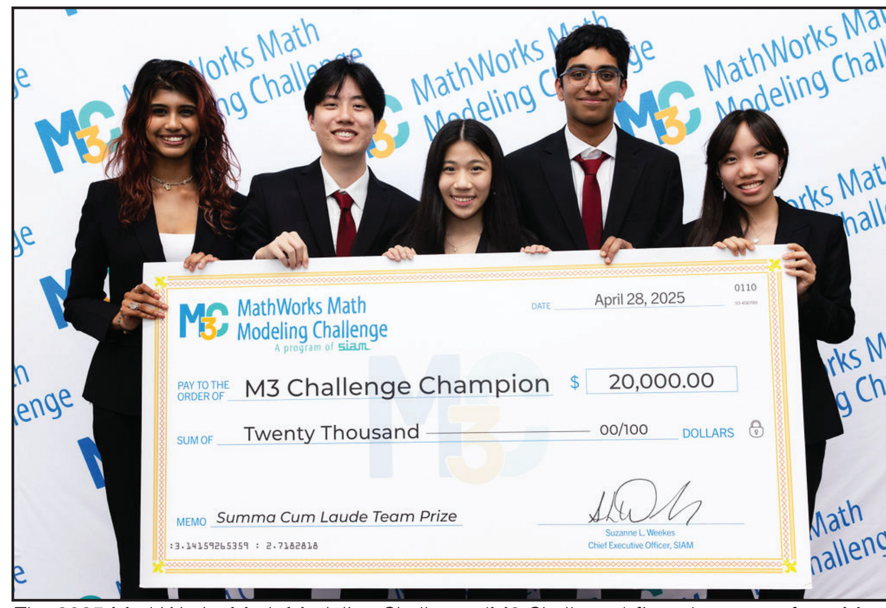


Ohio High Schoolers Awarded First Prize for Models of Heat Waves and Climate-driven Power Outages

SIAM's M3 Challenge 2025 Explores Residential Temperature Trends

By Lina Sorg

2024 was the Earth's warmest year on record, with global temperatures that exceeded the preindustrial average by 2.63 degrees Fahrenheit [1]. As temperatures around the world continue to climb in response to climate change, humanity must contend with a variety of troubling new weather phenomena — from melting polar ice and rising sea levels to droughts, catastrophic storms, and declining biodiversity.



The 2025 MathWorks Math Modeling Challenge (M3 Challenge) first-place team from Mason High School in Mason, Ohio, earned $20,000 in scholarship funds for their impressive models of residential temperature trends and energy usage during heat waves. They presented their winning solution at the M3 Challenge Final Event, which took place at Jane Street in New York City on April 28. From left to right: students Ramya Rajan, Raymond Shao, Vivian Tang, Aneesh Iyer, and Mingjia Zhang. SIAM photo.

One particularly dangerous consequence of global warming is the heightened incidence of heat waves: periods of dangerously hot weather that last for multiple days [4]. For more than 60 years, the frequency, duration, and intensity of U.S. heat waves has steadily increased [3]. These episodes disrupt the livelihoods and wellbeing of communities by overburdening healthcare organizations, emergency services, and energy providers — the latter of which leads to widespread power outages as the electrical grid struggles to accommodate the energy demands of air conditioning systems and other cooling measures [2]. Without electricity, homes fail to stay cool and critical infrastructure—businesses, transportation networks, hospitals, etc.—struggle to maintain operation. Such detrimental outcomes are exacerbated in urban areas in part due to the *urban heat island effect* [4].

Given the extensive societal repercussions of heat waves, this year's MathWorks Math Modeling Challenge[1] (M3 Challenge) focused on rising temperatures and energy usage during major heat events. M3 Challenge, a program of SIAM with MathWorks[2] as its title sponsor, is an annual internet-based mathematical modeling competition for 11th and 12th grade students in the U.S. and sixth form students in England and Wales. There are no registration fees, and participating teams of three to five individuals vie for over $100,000 in scholarship funds. During "Challenge Weekend," the teams download the real-world Challenge problem and have 14 consecutive hours to address the prompt with math modeling and produce a 20-page report that justifies their findings. 120 Ph.D.-level applied mathematicians then evaluate the papers during a triple-blind judging process, ultimately selecting nine finalist teams. On April 28, the 2025 finalists traveled to New York City and presented their solutions to a panel of judges at Jane Street, a quantitative trading firm.

"Nearly 800 teams submitted completed papers for review this year," SIAM chief executive officer Suzanne Weekes said during her remarks at the Final Event in New York City. "The papers of the teams in this room were read by between 15 and 18 professional mathematicians and subject to intense and sometimes heated evaluations."

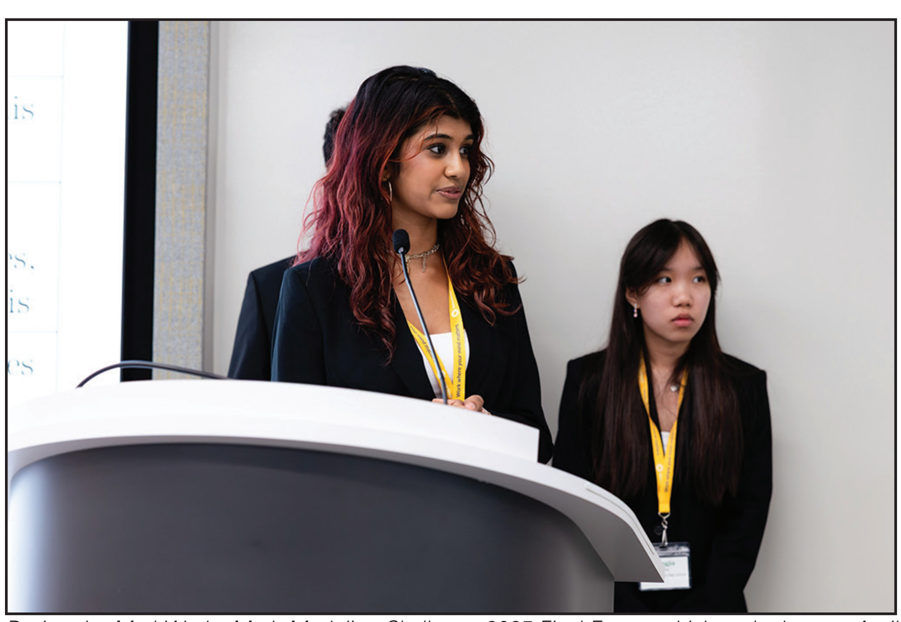
Jen Gorman of Lake Superior State University, Chris Musco of New York University (an M3 Challenge 2008 finalist himself), and Neil Nicholson of the University of Notre Dame—all members of the M3 Challenge Development Committee—authored this year's problem on heat waves. "We felt that the topic was both timely from an environmental point of view and impactful from a social point of view," Nicholson said. "We were seeing heat-related stories more and more in the national news, and those were often accompanied by social impacts. I really like how this question had a quantitative model and a broad social science modeling question."

The 2025 problem statement[3] involved three components. First, participants were asked to develop and test a model to predict the indoor temperature of any non-air-conditioned dwelling over a 24-hour period in Memphis, Tenn., or Birmingham, England. They next had to create a model to estimate the peak demand for their city's power grid during the summer months in both 2025 and 2045. Finally, teams generated and justified a vulnerability score for multiple neighborhoods to help policymakers equitably allocate resources and minimize the effects of a heat wave and/or power grid failure.

"Climate change presents complex, data-rich challenges that are deeply interdisciplinary, making it an ideal topic for mathematical modeling," said assistant professor Yuki Miura of New York University's Tandon School of Engineering, who spoke at the Final Event. "Forecasting atmospheric phenomena requires very complex models with a lot of computation effort, and modeling socioeconomic impacts that are triggered by extreme weather requires complex mathematical models. Anticipating these risks is essential to safeguard lives and build infrastructure that can withstand a changing climate."

This year's first-place team hailed from Mason High School in Mason, Ohio, and included Aneesh Iyer, Ramya Rajan, Raymond Shao, Vivian Tang, and Mingjia Zhang. To address the initial part of the Challenge problem, the group constructed a physical differential equation model—comprised of both a sinusoidal and quadratic model—to predict the indoor temperature of a non-air-conditioned home

See **Heat Waves** *on page 6*



During the MathWorks Math Modeling Challenge 2025 Final Event, which took place on April 28 at Jane Street in New York City, Ramya Rajan from Mason High School in Mason, Ohio, explains her team's winning solution to a panel of judges. Teammate Mingjia Zhang looks on in the background. SIAM photo.

[1] https://m3challenge.siam.org
[2] https://www.mathworks.com
[3] https://m3challenge.siam.org/resources/archives/2025-year-at-a-glance/2025-problem-hot-button-issue

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Dynamics of Behavior

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This approach works well if popular traits indeed reflect the mean, such as working hours or food portion sizes. However, the mean may not correctly indicate popularity in scenarios where beliefs are polarized to either end of a spectrum. For example, if half of a population holds political views on the far left and half prefers the far right, the mean is in the center — which does not correspond to any popular view. So, how can we surpass the simple conclusion that the mean is the most popular?

Denton and her colleagues Elisa Heinrich Mora, Michael Palmer, and Marcus Feldman of Stanford University address this open question in a recent study [2]. Building upon existing models, they present an enhanced mathematical framework that enables a nuanced exploration of the spread of cultural phenomena—like traits and beliefs—within a population. Unlike earlier models that assume discrete traits (i.e., variants), the new model incorporates a continuous range of traits.

Rather than define conformity as a preference for the mean cultural variant, the researchers view it as a preference for cultural variants that are most similar to each other (i.e., cluster together). "[This] work actively redefines how individuals interpret and respond to social information," Bergman, who was not associated with the study, said.

The collaborators consider a population of N individuals, each of whom possesses a cultural variant that is represented by a value from 0 to 1. Members of this population reproduce and generate a total of N offspring who each independently acquire a cultural variant under certain assumptions. First, every offspring randomly samples n role models from the previous generation. The offspring use these role models to create a probability distribution based on their levels of conformity, anti-conformity, or a neutral type of decision-making; this customized probability distribution then allows each offspring to adopt its own cultural variant. As the offspring become the new adult population in each generation, the steps repeat.

Given a sample of n role models, $\boldsymbol{x}=(x_1, x_2, x_3, \dots x_n)$ is the range of all sampled variants. If x_i is one such variant, it will have a probability of

$$P_k(x_i|\boldsymbol{x}) = \frac{1}{n} + \frac{g_{i,k}(\boldsymbol{x})d_k(\boldsymbol{x})}{n}. \qquad (1)$$

Here, $d_k(\boldsymbol{x})$ is a constant for a given role model sample $\boldsymbol{x}$, k is a parameter that calculates variants' distances from each other, and g captures the popularity of x_i. If x_i is popular, then it is more densely clustered near other variants than average and $g_{i,k}(\boldsymbol{x})$ is positive. If x_i is unpopular, it is further from the other variants than average and $g_{i,k}(\boldsymbol{x})$ is negative.

When conformity is present, $d_k(\boldsymbol{x})$ is positive. If $g_{i,k}(\boldsymbol{x})$ is also positive, then the probability of trait adoption is greater than $\frac{1}{n}$, i.e., $P_k(x_i|\boldsymbol{x}) > \frac{1}{n}$. For anti-conformity, $d_k(\boldsymbol{x})$ is negative and the reverse should be true, such that $P_k(x_i|\boldsymbol{x}) < \frac{1}{n}$ if x_i is popular. The more densely clustered (popular) variants should thus be adopted with a probability that is smaller than $\frac{1}{n}$, as anticonformists do not amplify popular variants (see Figure 1, on page 1).

In the instance of random copying—when neither conformity nor anti-conformity is present—the conformity coefficient $d_k(\boldsymbol{x}) = 0$. Here, $P_k(x_i|\boldsymbol{x}) = \frac{1}{n}$, implying that each of the n randomly sampled role models' cultural variants is selected with an equal probability of $\frac{1}{n}$.

Once an individual chooses a cultural variant x_i from their sample of role models based on the probability in (1), x_i becomes the mean of a normal distribution with standard deviation σ. This parameter σ introduces error into the model; if σ is not zero, then one may not copy the exact value of x_i.

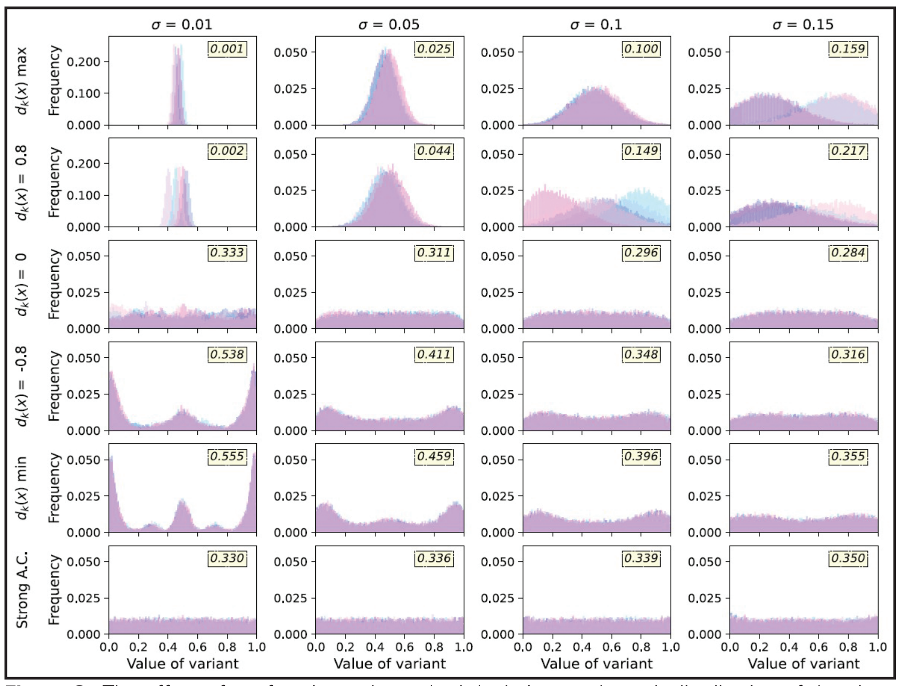

Figure 2. *The effect of conformity and standard deviation on the trait distribution of the simulated population after 100 generations. Figure courtesy of [2].*

To measure a variant's popularity, the researchers introduce a metric called k-dispersal that considers a variant's distance to its k closest neighbors. For example, imagine the hair length in inches of five different people: $\boldsymbol{x} = (5, 12, 12.5, 13, 20)$. The first and last variants of 5 and 20 inches are more dispersed from the other variants compared to the three middle values.

Consider a function $f_{i,k}(\boldsymbol{x})$, where f measures a given variant's distance from the rest of the sample. A variant's k-dispersal is denoted by $f_{i,k}(\boldsymbol{x})$, and the average k-dispersal of all variants in the sample of n role models is $\bar{f}_k(\boldsymbol{x}) = \sum_{i=1}^{n} f_{i,k}(\boldsymbol{x})/n$. Then, the value of $g_{i,k}(\boldsymbol{x})$ is positive and variant x_i is popular if it is less dispersed than average—that is, $f_{i,k}(\boldsymbol{x}) < \bar{f}_k(\boldsymbol{x})$—and vice versa.

The below equation captures positive g:

$$g_{i,k}(\boldsymbol{x}) = \frac{[f_{i,k}(\boldsymbol{x})]^{-1}}{\sum_{z\in \mathrm{II}} z^{-1}} \quad \text{if} \quad f_{j,k}(\boldsymbol{x}) > 0 \forall j \quad \text{and} \qquad (2)$$

$$f_{i,k}(\boldsymbol{x}) \in \mathrm{II}, \ \mathrm{II} = \{z: 0 < z < \bar{f}_k(\boldsymbol{x})\}.$$

Group $\mathrm{II} = \{z: 0 < z < \bar{f}_k(\boldsymbol{x})\}$ consists of dispersal values $f_{j,k}(\boldsymbol{x})$ in $\boldsymbol{x}$ that are lower than average but not zero. Here, x_i is closer to others (and thus more popular) than the average dispersion of variants. If we plug (2)—i.e., a positive value of g—into (1) along with conformity (i.e., $d_k(\boldsymbol{x}) > 0$), the probability of adopting the cultural variant is higher than the baseline probability of $\frac{1}{n}$.

If the reverse is true and the dispersal value $f_{i,k}(\boldsymbol{x})$ for x_i is higher than the average dispersal, then this quantity is captured in Group $\mathrm{I} = \{z: z > \bar{f}_k(\boldsymbol{x})\}$. In this scenario, g is negative:

$$g_{i,k}(\boldsymbol{x}) = -\frac{f_{i,k}(\boldsymbol{x})}{\sum_{z\in \mathrm{I}} z} \quad \text{if} \qquad (3)$$

$$f_{i,k}(\boldsymbol{x}) \in \mathrm{I}, \ \mathrm{I} = \{z: z > \bar{f}_k(\boldsymbol{x})\}.$$

When $d_k(\boldsymbol{x}) > 0$ and we insert negative g from (3) into (1), it produces a probability value that is less than $\frac{1}{n}$. Despite the presence of conformity, the variant is not popular and hence will not be amplified. As an example, (2) does not hold if some cultural variants in the sample are identical (i.e., $f_{i,k}(\boldsymbol{x}) = 0$). And if m cultural variants have k-dispersals of zero in this instance, then they each have the same g value of $1/m$.

When a trait's dispersal exactly equals the average dispersal, there is no basis as to whether it should be amplified. As a result, g becomes zero:

$$g_{i,k}(\boldsymbol{x}) = 0 \quad \text{if} \quad f_{i,k}(\boldsymbol{x}) = \bar{f}_k(\boldsymbol{x}). \qquad (4)$$

Plugging (4) into (1) yields a probability of adopting that view of just $\frac{1}{n}$.

"This work opens new paths for empirical research on real-world populations and sets the stage for more sophisticated models of collective behavior, cultural change, and adaptation," Bergman said.

While these equations describe an individual's adoption of a cultural variant, numerical simulations provide insights for a scaled population model. Figure 2 depicts trait distributions in a population of 10,000 individuals—each of whom selects traits from their own sample—that is simulated over 100 generations.

Given high conformity (top two rows of Figure 2) and relatively low σ, the population distributions seem to peak around the center of the trait distribution. This outcome implies that conformity sometimes incentivizes individuals to become more similar to the population mean, with lower population-level variance. As expected, increasing σ (left to right in any row of Figure 2) has a smoothing effect on distributions, whose peaks may fall to the left or right of the center.

Surprisingly, this study found that conformity does not necessarily lead to a homogenous population. While prior models identified a conformist's ideal trait value as the mean trait value in a population, Denton et al.'s model instead focuses on variant popularity. This new framework allows the researchers to define conformity as a disproportionate tendency to adopt a more clustered cultural variant (as opposed to the mean), and anti-conformity as the opposite tendency. For instance, Figure 2 illustrates a range of different cultural variant distributions, from narrow to broad. Unexpectedly, the group also found that high levels of anti-conformity cause a buildup of trait values near the edges, constituting high polarization. "This link between [conformity and homogeneity] is more nuanced than we thought," Denton said. "It depends on how you define the parameters in the model."

In the future, one could expand this model to incorporate personal beliefs. Extending the theoretical results to real-life population datasets could also yield further insights into the evolutionary dynamics of biases.

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Climate Research

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collaborations that include people whose lives are most affected by the research.

"We started Climate Change AI not out of the belief that AI will solve every problem in climate—nor that it's best suited for any problem—but out of the belief that there are places where AI is useful," Donti said. "There's a huge talent pool that is worth mobilizing to actually do that. In finding that community, you can take action on this issue."

Donti's AAAS co-presenter Elke Weber, a psychologist at Princeton University, agreed. She affirmed that AI can help identify rational climate interventions, thus aiding the decision-making process for nonscientists and promoting a sense of community. Weber considers this capability to be especially important in the U.S., noting that American society often places the burden of climate mitigation on individuals rather than collaborations and emphasizes single-action solutions over long-term acts on multiple fronts.

Stealing Water to Green the Grid

At the same time, even well-intentioned AI can be troublesome. All large-scale computations require energy, water to cool the computers, and natural resources to manufacture processors and other physical devices. In 2020, roughly 1.4 percent of global greenhouse gas emissions originated from the computing sector — a statistic that includes energy consumption and resource usage for building and operations (see Figure 1, on page 1) [2]. The creation and deployment of increasingly more computers will not solve the climate crisis if they simultaneously exacerbate the problem. Many data centers are located in water-stressed environments, so even those that utilize solar energy still consume other scarce resources.

As Eric Masanet of the University of California, Santa Barbara, pointed out during his AAAS talk, data centers had been becoming more energy and resource efficient until AI and cryptocurrency reversed that trend. However, actual usage data is incomplete due to the lack of transparency from utility and AI companies alike. One issue is that even "green" AI centers may still use fossil fuels while making promises to switch to renewables or nuclear power in the future [5, 6]. Masanet remarked that we do not yet know whether AI will help the world achieve net-zero carbon emissions or accelerate climate change, and Donti echoed those comments [3].

"It's great that there's more clean electricity on the grid, but none of our global decarbonization pathways account for an unlimited increase in the amount of electricity that we as a society are using," Donti said. In other words, adding more energy to the existing grid without addressing questions of efficiency does not reduce carbon emissions, which is the single most important factor in combatting climate change.

Cloud computing is another subtle issue that is associated with energy use in AI and other large-scale computations. For example, recent studies have found that cloud computing—which moves actively-running programs from local machines to distributed computers, perhaps in quite distant locations—adds hidden energy costs while bypassing some greenhouse gas regulations [4]. Again, transparency is key when accounting for actual consumption; current levels of ambiguity lead to genuine complaints of "greenwashing," i.e., pretending that something is more ecologically friendly than it actually is.

Hope, Despair, Doom, and Optimism

All three speakers acknowledged that none of these problems are specific to climate-centric AI applications. However, practitioners must remain aware of them if they wish to refrain from contributing to the same issues that they are trying to address.

On the technical side, Donti and her colleagues frequently use an older style of AI computation that begins with established physics-based models. In contrast, most contemporary efforts rely on more general machine learning algorithms that attempt to deduce a model from training data — a technique that is far less efficient in terms of the amount of necessary starting data and the energy consumption of the computations. Simply put, "smaller" thinking is not always a drawback when the goal is to improve both the scientific results and the underlying processes.

Weber also noted that generative AI chatbots and search engine insertion "summaries" from Google, X, and other online sources actively spread climate change misinformation and conspiracy theories. She advocated for a greater use of qualitative data and more input from fellow social scientists — a group whose expertise is often ignored in conversations on this topic.

Even more importantly, the three speakers collectively agreed that researchers who use AI to study climate change and mitigation tactics must consider vulnerable populations in their efforts, given that climate change disproportionately affects the people who are least likely to be consulted on questions about energy use, environmental impact, and so forth. Outreach, education, collaboration, and a heightened emphasis on social justice can all help increase representation.

In the end, AI is a tool that can be put to good or bad uses. Because its current implementation generally does not favor the climate, practitioners who utilize the technology must be especially cognizant of its drawbacks, not just its advantages.

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CSE25 Panel Considers the Fair and Responsible Use of Artificial Intelligence

By Lina Sorg

As the broadening impacts of artificial intelligence (AI) percolate through computational science and engineering (CSE) disciplines, a solid understanding of the technology's explainability, fair and responsible deployment, and theoretical underpinnings is becoming increasingly imperative. In recent years, the CSE community has refined several basic principles of AI, such as *fairness and bias mitigation*, *accountability*, *transparency*, and *privacy and data governance*. These areas are rife with research opportunities and can directly influence policy and decision-making processes as the field continues to evolve [1].

During the 2025 SIAM Conference on Computational Science and Engineering[1] (CSE25), which took place this past March in Fort Worth, Texas, a panel[2] of seasoned researchers shared their perceptions of AI's current and future trajectory. David Bindel of Cornell University—co-chair of the CSE25 Organizing Committee—moderated the session, which comprised panelists Patricia Kovatch of the Icahn School of Medicine at Mount Sinai (ISMMS), Manish Parashar of the University of Utah, Eric Stahlberg of MD Anderson Cancer Center, and Moshe Vardi of Rice University. Each panelist overviewed their individual experiences with AI before collectively fielding questions from the audience.

Bindel opened the session with some general thoughts about the omnipresence of AI in today's world. "It's hard to avoid discussions about AI right now," he said. "We're dealing with aspects of fairness and responsibility from both a technical and nontechnical perspective." He cited the Association for Computing Machinery's Conference on Fairness, Accountability, and Transparency[3] as an important forum for AI discourse, and noted that multiple organizations have published compelling reports about fair and responsible AI, such as the Institute of Electrical and Electronics Engineers' *Ethically Aligned Design* [6] and the European Commission's *Ethics Guidelines for Trustworthy AI* [5].

Vardi's presentation focused on *responsible AI*, a prevalent term that emerged in part due to widespread concerns about AI's safe implementation in present-day society. In keeping with the theme, Vardi shared the following definition of responsible AI that was generated by Google's Gemini chatbot: *Responsible AI is a growing consensus that AI development and deployment must prioritize ethical considerations, fairness, transparency, and accountability*. Yet despite its pervasiveness, Vardi has misgivings about this commonly accepted definition. "Responsible AI is a very vague term without saying who is really responsible," he said. "Responsibility should imply accountability. Responsibility should be people and organizations, not technology."

Instead, Vardi prefers the phrase "AI, responsibly," which puts a greater onus on people. "It is the social responsibility of computational science educators to educate socially responsible students," he said. "Social responsibility must be part of the computing curriculum" [2]. Beyond academia, Vardi asserted that corporations should adopt appropriate AI regulations to ensure that their products work for the benefit (rather than the detriment) of society. Such guidelines are especially important for projects that seek to maximize profits above all else, which introduces concerns about the concentration of exceptional levels of power in the hands of relatively few individuals [4].

Parashar offered a comparatively sanguine perspective on the utility of AI applications. "I take a very optimistic view of AI and think it has a lot of potential," he said. "But that doesn't mean we don't have to be responsible." He endorsed the U.S. National Institute of Standards and Technology's building blocks[4] of trustworthy and responsible AI: *validity and reliability*, *safety*, *security and resiliency*, *accountability and transparency*, *explainability and interpretability*, *privacy*, and *fairness and mitigation of harmful bias*. Some of these components require policy solutions—like the creation of regulatory frameworks—while others involve technological developments in algorithms and hardware.

"AI critically depends on computing, data, and technology," Parashar said. "One

See **Artificial Intelligence** *on page 7*

[1] https://www.siam.org/conferences-events/past-event-archive/cse25

[2] https://meetings.siam.org/sess/dsp_programsess.cfm?SESSIONCODE=83061

[3] https://facctconference.org

[4] https://www.nist.gov/trustworthy-and-responsible-ai

A group of researchers shared their thoughts and experiences with responsible artificial intelligence during a panel session at the 2025 SIAM Conference on Computational Science and Engineering, which took place in Fort Worth, Texas, this past March. From left to right: Eric Stahlberg of MD Anderson Cancer Center, Manish Parashar of the University of Utah, Moshe Vardi of Rice University, Patricia Kovatch of the Icahn School of Medicine at Mount Sinai, and moderator David Bindel of Cornell University. SIAM photo.

Heat Waves

Continued from page 2

in Memphis. "We developed a sinusoidal model to represent hourly temperature changes during a heat wave day, and a quadratic model to estimate solar radiation throughout the same period," Zhang said. "We then applied both models in a differential equation that accounts for these hourly temperature changes from solar radiation and heat transfer through exterior walls, along with the level of external shade, the geometric properties of the dwelling, and the material properties of the dwelling."

After testing their model with input parameters from provided datasets, the group concluded that shade coverage has a much larger impact on indoor temperature than wall insulation. "This highlights the need for Memphis to invest in more passive cooling measures, such as trees and other shade-producing objects, rather than investing directly in improving the walls of the individual home," Iyer said. "We also found that indoor temperatures peaked after exterior ones, which explains the real-world phenomenon of evening energy consumption being the greatest."

To predict the strain on Memphis' power grid now and in the future, the Ohio students defined peak demand in two ways: peak hourly load (in megawatts) and total energy consumption during the peak summer month (in kilowatt-hours). The team selected maximum annual temperature and annual population as key predictors, then ran a multiple linear regression in R. "Multiple linear regressions allow the incorporation of external predictors and capture their respective long-term trends, which are important to capture demand's demographic- and climate-based trends," Shao said. "They are also transparent in that they clearly show the effects of each predictor on the dependent variable, making our model easily interpretable to stakeholders in city planning or utilities."

The students used population projections, maximum annual peak temperature, and forecasted temperatures from five Shared Socioeconomic Pathways[4] (SSPs) emission scenarios to yield their demand estimates for 2025 and 2045. They reported that this year, Memphis power grids should be prepared to transmit 3,433.70 megawatts of power at any moment and anticipate roughly 887.50 million kilowatt-hours of total energy consumption in the height of the summer. In 2045, the grids can expect to transmit up to 3,563.07 megawatts of power and will see approximately 764.80 million kilowatt-hours of total energy consumption in the most demanding summer month.

Finally, the Mason team employed multiple linear regression to model the relationship between common heat wave vulnerability factors and the expected annual loss of several Memphis neighborhoods. They utilized backward variable selection to identify four important predictors of vulnerability: proportion of households with elderly individuals, proportion of households with children, population, and number of residents who walk or take public transit to work. Using the regression coefficients, the students combined, normalized, and scaled the predictors to generate a vulnerability score for each neighborhood.

"Our key takeaway was that vulnerability to heat waves is not evenly distributed across neighborhoods," Rajan said. "Factors like age demographics, transit usage, and access to shade significantly affect a community's ability to withstand extreme heat events." The students proposed several mitigative recommendations—including the installation of cooling centers in public buildings, shade structures at public transit stops, and tax incentives or rebates for homeowners who invest in shade solutions or passive cooling features—to alleviate the burden for people in vulnerable neighborhoods.

[4] https://earth.gov/sealevel/faq/124/what-are-shared-socioeconomic-pathways-or-ssps

After an impressive presentation in New York City, the Ohio students took home the top award of $20,000. "There was a lot to like about the Mason High School solution," Musco, who served as a judge in New York City, said. "Like many of the top teams, their paper stood out for consistent and in-depth modeling for all three questions. Another thing that stood out was the incorporation of SSPs scenarios, which are widely used in climate risk analysis; Mason was one of the only teams that effectively used this framework."

The 2025 event marked the 20th anniversary of M3 Challenge,[5] which first took place in 2006. In addition to the standard team prizes for the top six solution papers, the program has since grown to include monetary awards for technical computing; outstanding communication of results; and title 1 schools that develop solutions with passion, resourcefulness, and knowledge. "This important program continues to inspire young people to pursue education and careers in STEM fields," Karen Bliss, Senior Manager of Education and Outreach at SIAM, said. "Roughly 65,000 participants have collectively leveraged their math skills to tackle the biggest concerns facing our global communities, earning more than two million dollars in scholarship prizes. Participants also gain valuable skills that translate nicely to the workforce, including teamwork and the ability to communicate complex ideas in a straightforward fashion."

[5] https://go.siam.org/qoyyin

Colleen Everett—coach of the Mason High School team—appreciates M3 Challenge for allowing students to hone their mathematical modeling skills outside of the controlled classroom environment. "Modeling is what makes math feel real," she said. "It's how students take what they've learned in class and actually use it to make sense of real-world problems like climate change, the economy, or how to plan things efficiently. M3 Challenge gives them a chance to tackle problems that don't have clear-cut answers, kind of like what they'd face in careers in STEM, data science, economics, or public policy."

As the Mason students eagerly look towards college programs in mathematics, economics, engineering, and related fields, they intend to apply their newfound problem-solving and modeling competencies in higher education settings and eventually the workforce. "Participating in M3 Challenge has changed the way we approach problem solving," Tang said. "It taught us how to be comfortable with uncertainty and how to make decisions when the data is messy, the timeline is short, and there is no clear answer. It also showed us the value of collaboration under pressure and how to translate technical thinking into real-world impact."

Mason High School's winning solution paper is available online,[6] as is their final presentation.[7]

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[3] U.S. Environmental Protection Agency. (2025, April 18). *Climate change indicators: Heat waves*. Retrieved from https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves.

[4] World Health Organization: Health Topics. (2025). Heatwaves. *World Health Organization*. Retrieved from https://www.who.int/health-topics/heatwaves.

Lina Sorg is the managing editor of SIAM News.

[6] https://m3challenge.siam.org/wp-content/uploads/CHAMPION_Team18111_2025.pdf

[7] https://www.youtube.com/watch?v=gpFw4o_BZfc

Measuring Paper Thickness

MATHEMATICAL CURIOSITIES
By Mark Levi

As I was toying with some sheets of paper recently, the following puzzle came to mind: Given two identical sheets of paper and a tape measure, how can we estimate the paper's thickness? The paper must remain fully undamaged, indistinguishable from its original state. No other items are available.

Here is a possible way:

1. Stack the sheets on top of each other and squeeze them together at one end (A) to prevent relative sliding (see Figure 1).

2. Bend the sheets as shown in Figure 1, allowing them to slide relative to each other at the other end (B). Apply gentle sliding forces—indicated by the small arrows at B—to ensure that the sheets touch along their entire length without gaps. The ends at B will shift relative to each other by a very small amount δ, which is too small to measure with a tape measure.

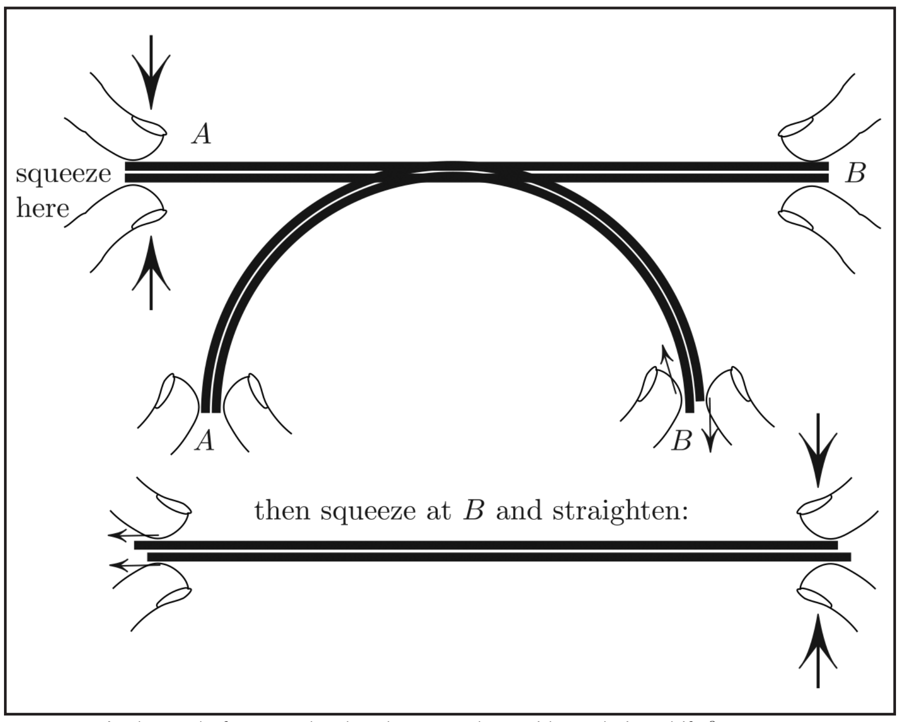

Figure 1. *At the end of one cycle, the sheets end up with a relative shift δ.*

3. Squeeze the sheets together at B to prevent sliding, so as to fix δ. Relax the squeeze at A and straighten the sheets; they will end up with a tiny shift δ that is again too small to measure with a tape measure.

4. Repeat this cycle n times (with the n of your choice) to accumulate a measurable shift Δ_n, thus finding $\delta = \Delta_n/n$ (see Figure 2).[1]

We can now recover the paper's thickness ε from the shift. It turns out that

$$\varepsilon = \frac{\delta}{\theta}, \qquad (1)$$

where θ is the angle by which the sheets were bent. In Figure 1, $\theta = \pi$.

With two sheets of regular printer paper, I measured $\Delta_3 = 1$ millimeter (mm), with an error smaller than my eye could see. Then, $\delta = \Delta_3/3 = 1/3$ yielded

$$\varepsilon \approx 0.1 \text{ mm},$$

the right order of magnitude (although less accurate than folding the paper into many layers and dividing the thickness of the stack by the number of layers[2]).

Must the bend in Figure 1 be circular? Interestingly, (1) holds for any shape; the only thing that matters is the angle θ between the tangents at the two ends.

Proof of (1) for Circular Arcs

Figure 3 (on page 8) shows the midlines of two sheets that are bent through angle θ into circular arcs. The thickness ε that we seek is also the distance between the sheets' midlines. The two arcs have the same length:

$$R(\theta + d\theta) = (R + \varepsilon)\theta.$$

See **Paper Thickness** *on page 8*

[1] At first glance, it may seem like the shift δ will decrease slightly after each consecutive cycle because the overlap will shorten a bit. But this is not the case; the shift does not depend on the length of the overlap according to (1).

[2] Of course, paper is cheap enough that we can afford to ruin a sheet by folding it into many layers and dividing the stack's thickness by the number of layers. The method that I describe here is only a curiosity and is not meant for practical use.

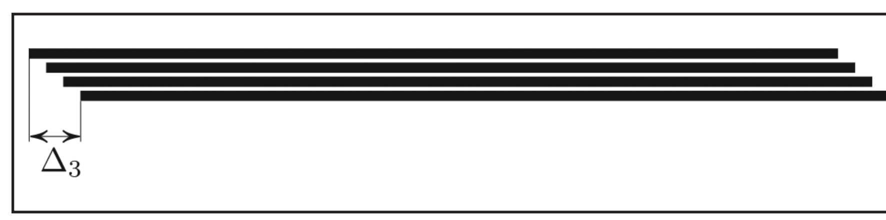

Figure 2. *After n cycles ($n = 3$ here), the shift Δ_n becomes large enough to measure and yields $\delta = \Delta_n/n$.*

Artificial Intelligence

Continued from page 5

technical challenge is understanding the quality of the data that goes into the AI and trusting that data. But we also know that to achieve the attributes of being responsible, it's important that a diversity of folks have access to the technology." Data diversity is similarly crucial because AI technologies and infrastructures evolve according to their inputs. "Greater inclusivity in contributions to research and development increases the diversity of approaches, quality of research, and fairness of the results," Parashar continued.

Several ongoing efforts aim to democratize AI research and development and overcome barriers—such as a lack of awareness or access to resources—that preclude the realization of fair and responsible AI. For instance, the U.S. National Science Foundation's National Artificial Intelligence Research Resource pilot[5] seeks to strengthen the AI innovation ecosystem while protecting people's privacy, rights, and civil liberties. Likewise—and closer to home for Parashar—the University of Utah's One-U Responsible AI Initiative[6] intends to responsibly advance translational AI for societal good in target areas like education, the environment, and healthcare while simultaneously safeguarding civil rights and promoting fairness, accountability, and transparency.

In healthcare settings, the improper deployment of AI can compromise patient needs or wellbeing [3]. Stahlberg, who leads MD Anderson's Institute for Data Science in Oncology[7] (IDSO), identified six essential aspects of data that are necessary to establish trust in AI applications: *context*, *quality*, *provenance*, *transparency, portability*, and *understanding*. Scientists must consider how data is collected, shared, and utilized, and how the surrounding policy and governance structures are managed. Careful attention to these questions can help healthcare organizations build ecosystem capacity; alleviate barriers; and empower patients, communities, researchers, and practitioners. The goal is to jumpstart a recurrent cycle that allows practitioners to effectively transform challenges and opportunities into tangible, impactful results within clinical settings — thus informing future innovation and learning.

As MD Anderson strives to be this point of translation, IDSO is cultivating a team-based culture that embraces data science across various domains. The institute is exploring a range of data-centric tools, including the *digital twin*. "Digital twins are one thing that I really champion because they pull all of this stuff together," Stahlberg said. However, their implementation is often complicated by social, technical, and financial difficulties. For example, practitioners must obtain appropriate stakeholder buy-ins; set realistic expectations; establish a baseline healthy state for patients; obtain quality data; and manage regulatory, privacy, and liability concerns. "We also have to have methodologies of trust," Stahlberg said. "How can we be economical in the mathematics but still maintain integrity, trust, and reliability?"

To address these concerns, Stahlberg and his colleagues are educating patients, AI developers, and the general public about fair and responsible use. "Improving healthcare options through data science in cancer is a team effort," he said. "Quality data, processes, and people are essential to the collective effort for robust translational data science. Collaborations across boundaries are key to continued innovations and sustained impact."

Much like MD Anderson, ISMMS conducts basic research that is translated into clinical settings and returned to the cycle via a feedback system. "Mount Sinai has been transforming care delivery with AI for over 10 years," Kovatch, the Dean for Scientific Computing and Data at ISMSS, said. "There's enormous potential for further impact." Several years ago, ISMMS founded the Windreich Department of Artificial Intelligence and Human Health[8]—one of the first such departments in the country—to improve diagnoses, expedite drug discovery, and deliver personalized care to patients.

Yet even with this advances, Kovatch acknowledged certain obstacles that inhibit AI's successful implementation in the medical sphere. For instance, differences in processing abilities between healthcare systems limit data sharing. And human activity frequently introduces errors into the data, such as when a patient fails to take their medication or a receptionist incorrectly records someone's race, gender, or age. Kovatch encouraged cooperation between applied mathematicians, computer scientists, healthcare workers, and other stakeholders to tackle these impediments. "We need to find a common language so we can work on these problems together," she said.

Given the unavoidable uncertainties, Mount Sinai follows a set of core principles to promote a comprehensive understanding of the risks and benefits of AI tools. Decision-makers ask the following four questions of any proposed AI software: (i) *Is it safe?* (ii) *Is it effective?* (iii) *Is it equitable?* and (iv) *Is it ethical?* The Mount Sinai AI Review Board for Governance then employs a five-step checkpoint system—pre-triage, evaluation, validation, deployment, and quality assurance—to evaluate an intended project or technology. "It's at least an initial framework to make some decisions as to whether the models are doing what we think they should," Kovatch said. "It can help us set priorities."

To ensure that practitioners and institutions uphold the principle of "do no harm" in the changing medical landscape, Vardi advocated for a national AI safety board to establish universal guidelines for AI in healthcare. "If AI is going to be involved in making decisions about human health, we need to figure out the standards," he said. Researchers must be able to mathematically explain possible sources of harm and provide mitigative solutions to prove that a system is sufficiently reliable. "We don't have perfect safety, so we have to develop standards where it's safe *enough*," he continued, likening the situation to air travel — airline passengers may not know for absolute certain that a system won't fail, but they can nevertheless feel comfortable with the diminutive risk.

As the panel drew to a close, the speakers emphasized the collaborative aspects of AI development. "AI is evolving based on how you use it," Parashar said. "It's not just about how you build it, but how the community is engaging with it." He urged audience members to foster a general sense of awareness and appreciation of AI, from the early stages of research to ultimate deployment. This type of open communication is especially important if no governmental or organizational guardrails are in place. "You need to be transparent about how you're using AI," Stahlberg said. "Share with others when you've been successful and when you've failed."

Despite the many challenges that are associated with fair and responsible AI, the panelists remain hopeful about AI's expanding capacity in the coming years — as long as practitioners adhere to appropriate protocols. "I'm extremely optimistic about the potential of AI," Parashar said. "It's a huge resource that we can leverage."

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Mathematics in Action: Launching the Loyola University Chicago SIAM Student Chapter

By Lily Ingram, Anaum Chaudhry, and Sarah Riaz

Loyola University Chicago (LUC) has officially launched a new SIAM student chapter[1] that serves as an exciting platform for members to engage with applied mathematics and computational science. The chapter aims to foster collaboration, professional development, and research opportunities for students who are interested in real-world mathematical problems. To select the inaugural chapter leadership, faculty sponsors Xiang Wan and Tuyen Tran held elections that resulted in the appointment of Lily Ingram (economics major, class of 2025) as president, Anaum Chaudhry (data science major, class of 2027) as vice president, and Sarah Riaz (statistics major, class of 2026) as treasurer.

The LUC SIAM Student Chapter held several successful events during the 2024-2025 academic year and established a strong presence on campus. Its first activity was an informational meeting for interested students in October 2024 that highlighted the offerings of the new chapter, including access to conferences and industry resources. A few days later, students and faculty attended the 2024 SIAM Great Lakes Section Annual Meeting[2] at Purdue University Northwest, where they enjoyed a variety of minisymposia, invited and contributed talks, and networking opportunities.

In late October, Sven Leyffer of Argonne National Laboratory[3] (then-President of SIAM) visited the chapter and delivered a colloquium about his research on topological design problems that are formulated as massive mixed-integer partial differential equation (PDE)-constrained optimization (MIPDECO) problems. Leyffer demonstrated that one can efficiently solve MIPDECOs at a computational cost that is comparable to a single continuous PDE-constrained optimization solution. He also detailed two key classes of solution methods: rounding techniques that are asymptotically optimal and trust-region approaches that converge under mesh refinement.

The LUC SIAM Student Chapter kicked off the 2025 spring semester with a Pi Day celebration on March 14, in collaboration with the LUC Math & Stats Club.[4] Attending students and faculty discussed the history and applications of π, competed in brain games, and enjoyed complementary pie and refreshments.

[1] https://loyolachicagosiam.github.io

[2] https://sites.google.com/view/2024glsiamatpnw/home

[3] https://www.anl.gov

[4] https://www.luc.edu/math/mathclub.shtml

The Loyola University Chicago (LUC) SIAM Student Chapter and LUC Physics Club visit Argonne National Laboratory in March 2025. SIAM Past President Sven Leyffer (front row, second from right) provided a tour of the facilities. Photo courtesy of Mary Dzielski.

On March 29, Leyffer hosted both the chapter and the LUC Physics Club[5] at Argonne National Laboratory. Roughly 45 student and faculty participants visited the Advanced Photon Source,[6] Aurora exascale supercomputer,[7] and an exhibit on nuclear history. This successful excursion introduced chapter members to high-level research within a national laboratory setting and got them thinking about possible careers in research and development.

Two days after the Argonne visit, a seminar with Zeyu Zhou of Carl Zeiss X-ray Microscopy, Inc.[8] marked the chapter's final event for the 2024-2025 academic year. Zhou visited LUC and delivered a talk about computed tomography (CT) and its uses in medical diagnostics, industrial inspection, and scientific research. The audience received a comprehensive overview of CT and its scientific principles, mathematical foundations, and practical applications. Additionally, Zhou used concepts such as reconstruction algorithms, phantom calibration, and artifact removal to explore the acquisition and reconstruction of X-ray projections; he also described CT's real-world applications in image denoising and defect analysis.

The LUC SIAM Student Chapter experienced a very successful first year of operation, having developed a prominent on-campus presence and pursued several high-impact visits to offsite conferences and laboratories. The chapter looks forward to its next set of activities in the 2025-2026 academic year, which will continue to provide avenues for students to explore diverse applications of applied mathematics and computational science in society.

Lily Ingram is pursuing a master's degree in mathematics at Loyola University Chicago (LUC). She is the inaugural president of the LUC SIAM Student Chapter and graduated from LUC in May 2025 with a degree in economics and a minor in mathematics. Anaum Chaudhry is an undergraduate student at LUC who studies data science and information systems. She is vice president of the LUC SIAM Student Chapter. Sarah Riaz is an undergraduate student at LUC who studies statistics, mathematics, and data science. She is treasurer of the LUC SIAM Student Chapter.

[5] https://www.luc.edu/physics/physics_club.shtml

[6] https://www.aps.anl.gov

[7] https://www.anl.gov/aurora

[8] https://www.zeiss.com/microscopy/us/home.html

Members of the Loyola University Chicago (LUC) SIAM Student Chapter attend the 2024 SIAM Great Lakes Section Annual Meeting, which took place at Purdue University Northwest in October 2024. Photo courtesy of the LUC SIAM Student Chapter.

Paper Thickness

Continued from page 7

Solving for ε, we get

$$\varepsilon = \frac{Rd\theta}{\theta} = \frac{\delta}{\theta},$$

as claimed.

Proof of (1) for Arbitrary Arcs

Figure 4a shows two curves that are separated by a fixed distance ε. Their lengths L and ℓ are related by

$$L = \ell + \varepsilon\theta, \qquad (2)$$

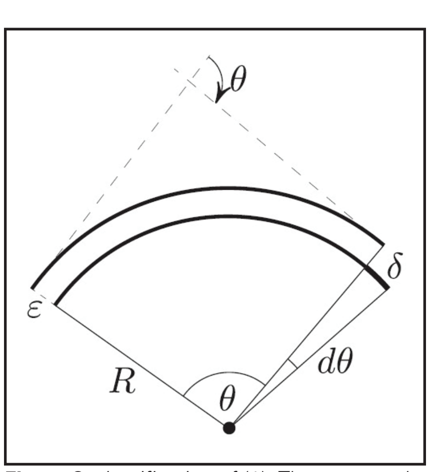

Figure 3. *Justification of (1). The arcs are the midlines of the paper sheets.*

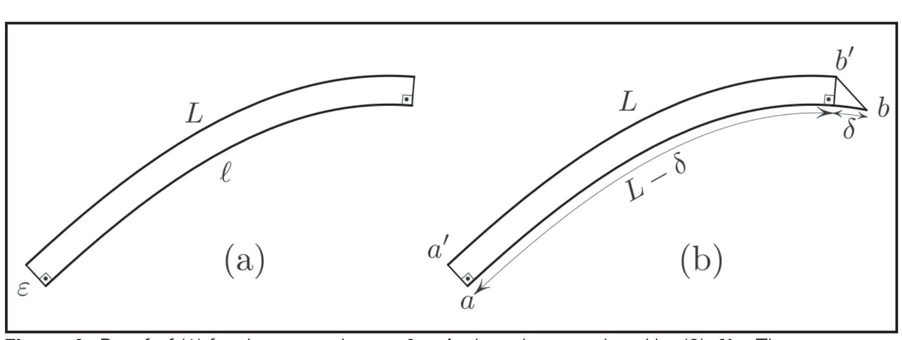

Figure 4. *Proof of (1) for the general case.* **4a.** *Arclengths are related by (2).* **4b.** *The two curves have equal lengths so that $\delta = L - \ell$.*

where θ is the angle between the tangents at the two ends of the curves (tangents to the two curves are parallel at the corresponding points, where correspondence means that the points lie on the common normal to both curves). Applying this remark to our two midlines in Figure 4b yields

$$L = \underbrace{(L-\delta)}_{\ell} + \varepsilon\theta,$$

which again gives (1).

Another Way

We could also prove (1) for general curves by using the statement for the circular case and cutting the "railroad track" in Figure 4 into pairs of short arcs with many normal lines. We can approximate these arcs with osculating circles to which the earlier proof applies; I omit the details, mentioning only that the circular case applies because the osculating circles at the corresponding points are concentric (as follows from the fact that the distance $\varepsilon = \text{const.}$).

It may also be interesting to observe that the lines aa' and bb' in Figure 4 are almost parallel. In a linear approximation, the angle between these lines is

$$\theta - \tan^{-1}\theta,$$

which for small θ is indistinguishable from zero in practice.

The figures in this article were provided by the author.

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Information is current as of May 21, 2025. Visit *siam.org/conferences* for the most up-to-date information.

Upcoming SIAM Events

SIAM Conference on Applied Algebraic Geometry
July 7–11, 2025
Madison, Wisconsin, U.S.
Sponsored by the SIAM Activity Group on Algebraic Geometry

SIAM Conference on Financial Mathematics and Engineering
July 15–18, 2025
Miami, Florida, U.S.
Sponsored by the SIAM Activity Group on Financial Mathematics and Engineering

The Third Joint SIAM/CAIMS Annual Meetings
July 28–August 1, 2025
Montréal, Québec, Canada

SIAM Conference on Control and Its Applications
July 28–30, 2025
Montréal, Québec, Canada
Sponsored by the SIAM Activity Group on Control and Systems Theory

SIAM Conference on Computational Geometric Design
July 28–30, 2025
Montréal, Québec, Canada
Sponsored by the SIAM Activity Group on Geometric Design

SIAM Conference on Applied and Computational Discrete Algorithms
July 30–August 1, 2025
Montréal, Québec, Canada
Sponsored by the SIAM Activity Group on Applied & Computational Discrete Algorithms

SIAM Conference on Mathematical and Computational Issues in the Geosciences
October 14–17, 2025
Baton Rouge, Louisiana, U.S.
Sponsored by the SIAM Activity Group on Geosciences

2nd SIAM Northern and Central California Sectional Conference
October 27–28, 2025
Berkeley, California, U.S.

SIAM Conference on Analysis of Partial Differential Equations
November 17–20, 2025
Pittsburgh, Pennsylvania, U.S.
Sponsored by the SIAM Activity Group on Analysis of Partial Differential Equations

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Recipients Named for Annual SIAM Student Chapter Certificates of Recognition

SIAM Student Chapter certificates of recognition were awarded to students who made outstanding contributions to their SIAM Student Chapters. This program recognizes the importance of student contributions in creating and sustaining exciting chapters, acknowledges students' efforts within the greater SIAM community, and provides a noteworthy commendation for students to add to their portfolio for career building.

SIAM congratulates all the recipients and thanks them for their contributions to the development and growth of the SIAM Student Chapters program.

2025 SIAM Student Chapter Certificate of Recognition Recipients:

Christian Austin, University of Florida
Alexander Bastien, University of Evansville
Ivan Bioli, Università Di Pavia
Cara Connelly, Eastern Washington University
Kirsty Cowie, University of Strathclyde
Haridas Das, Oklahoma State University
Nishka Desai, Rochester Institute of Technology
Katherine Henneberger, University of Kentucky
Payton Howell, University of Washington
Matthew Howells, Cardiff University
Lily Ingram, Loyola University Chicago
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Jack McErlean, Duke University
Andrés Miniguano-Trujillo, Heriot-Watt University and University of Edinburgh
Kristina Moen, Colorado State University
Md Al Amin Molla, University of New Mexico
Yu-Ru Pai, National Cheng Kung University
Syed Raza, Wayne State University
Francisca Muñoz Riquelme, Pontificia Universidad Católica de Chile
Oscar Escobar Rodriguez, Brigham Young University
Purusharth Saxena, Heidelberg University
Jonas Schulze, Magdeburg University
Laura Sobarzo, Pontificia Universidad Catolica de Valparaíso
Kota Takeda, Kyoto University
Franziska Thoma, University of Potsdam
Urvashi Verma, Iowa State University
Samuel Ward, Southampton University
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Yuerong Wu, Georgia State University
Maximilian Wuerschmidt, Trier University
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Want to get involved in your section? Sections are a great way to gain experience in organizing meetings and SIAM leadership. Contact us today to put you in touch with the current leadership in your section. Email *sections@siam.org* with any questions you may have.

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SIAM welcomes our newest student chapter:

New York Institute of Technology

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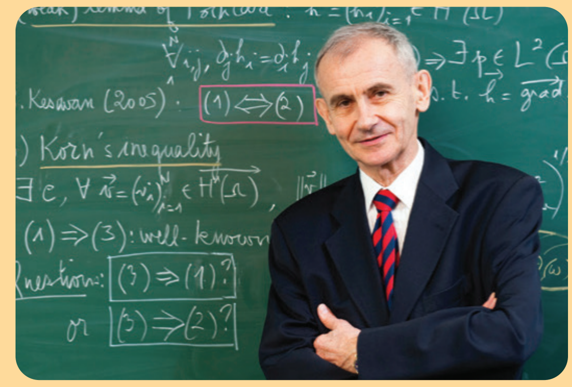
SIAM | BOOKS

Quality and Value in Mathematical Science Literature

Linear and Nonlinear Functional Analysis with Applications, Second Edition

An Interview with the author, Philippe G. Ciarlet



Who were your major influences?

I had the good fortune to follow the "Cours d'Analyse" of Laurent Schwartz when I was a student at l'Ecole Polytechnique in Paris. He was an outstanding teacher and, as such, was the origin of my desire to learn more mathematics and teach mathematics and perhaps even pursue an academic career in mathematics, although at that time I did not have the faintest idea of what "academic career in mathematics" actually means.

Then I went to the United States to get a Ph.D. under the illuminating guidance of Richard S. Varga, a very influential numerical analyst and approximation theorist. I am very grateful for his teaching me how to write mathematics and do research. In so doing, he developed my enthusiasm for pursuing an academic career in mathematics, an enthusiasm that never decreased with time!

A third mathematical encounter with another great master was with Jacques-Louis Lions, who directed my thèse d'état—the equivalent of a habilitation—in Paris, and initiated me into the arcana of partial differential equations, the calculus of variations, and especially to their applications to the real world.

I also owe a lot to Robert Dautray, the co-author of the "Dautray-Lions" (*Mathematical Analysis and Numerical Methods for Science and Technology*), widely regarded as the modern version of the celebrated "Courant-Hilbert" (*Methods of Mathematical Physics*). He strongly encouraged me to always keep an eye on applications in my research interests.

It is thanks to the influences of these great mathematicians that I decided to pursue a career in mathematics.

What do you enjoy most about teaching and working with students?

I always enjoyed teaching, for at least three reasons: First, there is no better way to understand a theorem and its proof than to teach them; otherwise, one often misses the main difficulties or technicalities and does not understand the depth of the result. Another reason is the feedback from students, which can often substantially improve the quality of teaching and the understanding of the subjects taught by the instructor. But, of course, the major reason is the pure joy of transmitting knowledge "in a human way" in contrast with the "dry" on-line teaching.

Why did you decide to write LNFAA?

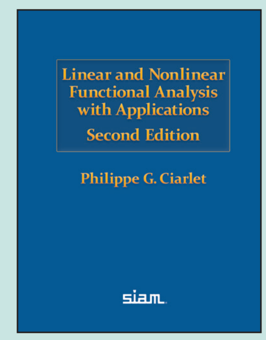
Indeed, there are already many excellent textbooks on functional analysis, so why to write another one? There are least four reasons for this.

The first, which is purely subjective and which I therefore cannot rationally explain, is that I like to write books, just like other people like classical music, or impressionism, or to play chess, etc., and also to a more minor extent, I like to draw mathematical figures (I regret that contemporary textbooks usually do not have many figures). And indeed there are plenty of figures in my book (80 in total).

The second reason, this time more rational, is that there are very few texts that assemble in a single volume the most basic theorems of both linear and nonlinear functional analysis.

The third reason is, like in my other texts, I wished to provide complete proofs of all the basic theorems, without relegating some (sometimes crucial) parts of a proof to exercises, or simply "to the reader", which can be quite frustrating, especially when a text is used for self-study.

The fourth reason is that I wanted to illustrate, by means of plenty of examples, how "analysis" and "functional analysis" play such significant roles in applications and in the justification of numerical algorithms.



This new, considerably expanded edition covers the fundamentals of linear and nonlinear functional analysis, including distribution theory, harmonic analysis, differential geometry, the calculus of variations, and degree theory. Numerous applications are included, especially to linear and nonlinear partial differential equations and to numerical analysis. All the basic theorems are provided with complete and detailed proofs. The author has added more than 450 pages of new material and more than 210 problems. Two entirely new chapters, one on locally convex spaces and distribution theory and the other on the Fourier transform and Calderón–Zygmund singular integral operators, have also been added. In addition, the chapter on the "great theorems" of nonlinear functional analysis has been enlarged and split into two chapters, one on the calculus of variations and the other on degree theory.

2025 / xviii + 1287 pages / Hard / 978-1-61197-823-0
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How did you come to work on the second edition of the book and how does it differ from the first?

This is a considerably enlarged edition, with more than 450 pages of supplementary material and more than 200 new problems and which, like the original edition, took me another ten years to write.

What led me to consider writing such a second edition was that even though the first edition was well received and used as a text in many graduate courses, some important topics were not covered. In this direction I am particularly grateful to several colleagues, who suggested specific new topics, such as locally convex spaces, distribution theory, the Fourier transform, the Hilbert transform, Calderón-Zygmund singular integrals, the M. Riesz-Thorin and Marcinkiewiz interpolation theorems, the Hardy-Littlewood maximal function, spectral analysis in infinite-dimensional spaces, the isoperimetric inequality, the Weingarten map, tensors on a surface, geodesics on a surface, introduction to gamma-convergence, and, especially, the Leray-Schauder degree with its beautiful applications to the Krasnoselskii and Rabinowitz bifurcation theorems.

Is there anything else you'd like to tell readers about the book?

A new feature is that the complete solutions of all the 617 problems, co-authored with Cristinel Mardare, will be uploaded progressively on a dedicated website (freely accessible by those who bought the hard copy or its e-version). This feature should be well-received by instructors as well as by students, or by anyone interested in self-study.

What does SIAM mean to you?

SIAM means a lot for me. Not only because I am one of its earliest members (since 1966 if my memory is correct), but also because I am lucky enough to have authored six books, at least to this day..., published by SIAM, each time with an exemplary collaboration, letting me complete freedom in such practical, but very important in my eyes, matters, such as the choice of fonts, the use of indentations, of italics versus boldface, etc., regarding the general appearance of the text.

I wish to strongly emphasize that it is a blessing that the texts that SIAM publishes are reasonably priced, contrary to the policy of some other publishing houses, thus making them quite accessible to students (even if, unfortunately, this does not eliminate the scourge of "uncopyrighted" pdf files that are available on the web!).

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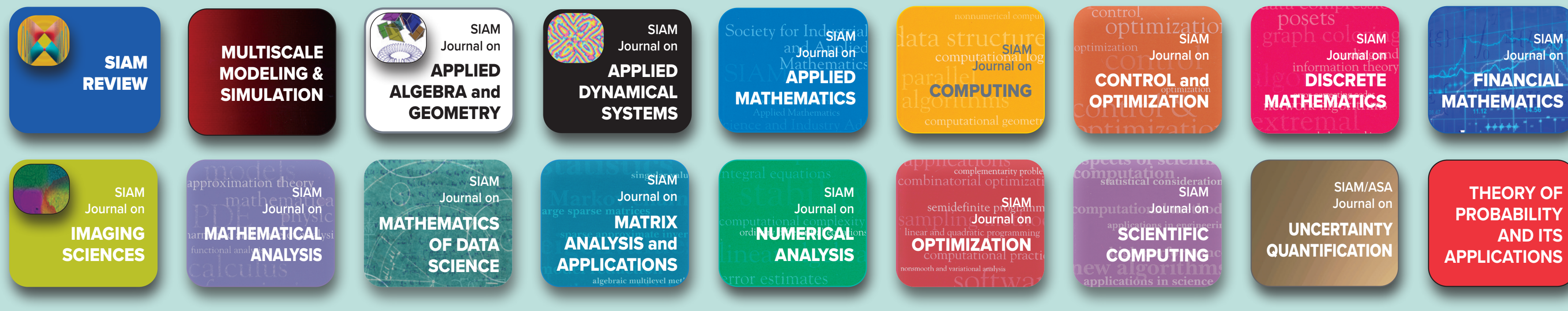
SIAM JOURNALS

Where You Go to Know and Be Known



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